Appendix A. LPGS Requirements Traceability Matrix

Rqmt. No.	Requirement Summary	PCS	DMS	RPS	GPS	QAS	AAS	UI	GL	HW	OPS
3.1	System-Level Requirements										
3.1.1	The LPGS shall nominally generate L1 data products on a first-ordered, first-processed (FIFO) basis.	X									
3.1.2	The LPGS shall provide the capability to move a Level 1 image processing work order within the FIFO queues according to operator direction.	X									X
3.1.3	Deleted										
3.1.4	Deleted										
3.1.5	The LPGS shall provide the capability to generate and report LPGS error messages.	X	X	X	X	X	X	X			
3.1.6	The LPGS shall provide an interactive capability to facilitate detection and correction of abnormal system conditions.	X	X	X	X	X	X	X		X	X
3.1.7	The LPGS shall provide the capability to isolate system faults.	X								X	X
3.1.8	The LPGS shall provide the capability to recover from system faults.	X								X	X
3.1.9	The LPGS shall provide the capability to test LPGS functions and external interfaces.	X	X	X	X	X	X	X		X	X
3.1.10	The LPGS shall provide the capability to support attended operations 24 hours a day, 7 days a week, on a continuous basis.	X	X	X	X	X	X	X	X	X	X
3.1.11	The LPGS shall provide the capability to support unattended, automatic processing 16 hours a day, 7 days a week, on a continuous basis.	X	X	X	X	X		X	X	X	X

Rqmt. No.	Requirement Summary	PCS	DMS	RPS	GPS	QAS	AAS	UI	GL	HW	OPS
3.1.12	The LPGS shall provide the capability to support Landsat 7 operations for a minimum mission life of 5 years.	X	X	X	X	X	X	X	X	X	X
3.1.13	The LPGS shall provide the capability to execute diagnostic tests for verifying proper operation of system capabilities and components.	X	X	X	X	X	X	X		X	X
3.1.14	The LPGS shall provide the capability to support end-to-end testing of Level 1 processing functions.	X	X	X	X	X	X	X		X	X
3.1.15	The LPGS shall provide the capability to control LPGS operations.	X						X			X
3.1.16	The LPGS shall provide the capability to monitor LPGS operations.	X						X			X
3.1.17	The LPGS shall provide the capability to reconfigure LPGS system resources.	X						X		X	X
3.1.18	The LPGS shall provide the capability to support software upgrades while supporting normal operations.	X	X	X	X	X	X	X	X	X	X
3.1.19	The LPGS shall be capable of making all software and databases used in operations accessible to ECS for archiving.		X							X	X
3.1.20	The LPGS design shall be scaleable to allow for future growth in processing capability.	X	X	X	X	X	X	X	X	X	
3.1.21	The LPGS shall be able to generate level 1 digital images corresponding to either heritage world-wide reference system (WRS) scenes or to a partial ETM+ subinterval up to an area equivalent to three WRS scenes.				X	X					
3.1.22	The LPGS shall be capable of recovering from failures and aborts in a controlled manner.	X	X	X	X	X	X	X	X	X	
3.2	External Interface Requirements										
3.2.1	LPGS shall interface with the ECS to receive the following:										

Rqmt. No.	Requirement Summary	PCS	DMS	RPS	GPS	QAS	AAS	UI	GL	HW	OPS
3.2.1.1	L0R files (includes associated PCD, MSCD, and calibration parameter files)		X							X	
3.2.1.2	Level 1 image processing requests		X							X	
3.2.1.3	Data availability notification		X							X	
3.2.1.4	Production status requests		X							X	
3.2.1.5	Product cancellation requests		X							X	
3.2.1.6	Product problem report (trouble ticket)		X							X	
3.2.2	LPGS shall interface with the ECS to coordinate transfer of the following:										
3.2.2.1	LPGS L1 digital images		X							X	
3.2.2.2	Processing status		X							X	
3.2.2.3	Production quality and accounting information		X							X	
3.2.2.4	L1 processing statistics		X							X	
3.2.2.5	L1 metadata		X							X	
3.2.2.6	PCD file (consensus)		X							X	
3.2.2.7	MSCD file (consensus)		X							X	
3.2.2.8	IC data file		X							X	
3.2.2.9	CPF		X							X	
3.2.2.10	Geolocation table		X							X	
3.2.3	The LPGS shall interface with the Image Assessment System (IAS) to provide Level 1 radiometric characterization data.		X	X						X	
3.2.4	LPGS shall interface with the DHF to provide L1 processing anomaly reports.		X			X	X			X	X
3.3	Functional Requirements										
3.3.1	Retrieve L0R files.										
3.3.1.1	The LPGS shall provide the capability to receive L0R data inputs from the ECS. This data shall include the following items:		X								
3.3.1.1.1	Level 1 image processing request that includes the following:										
3.3.1.1.1a	Selected coordinate reference system for map projection		X							X	

Rqmt. No.	Requirement Summary	PCS	DMS	RPS	GPS	QAS	AAS	UI	GL	HW	OPS
3.3.1.1.1b	Requested orientation (Nominal Path or North Up)		X							X	
3.3.1.1.1c	Variable grid cell size selection		X							X	
3.3.1.1.1d	Output format selection		X							X	
3.3.1.1.1e	Resampling filter		X							X	
3.3.1.1.1f	Selected bands		X							X	
3.3.1.1.1g	Selected scene or subinterval identification		X							X	
3.3.1.1.1h	L1R or L1G image processing selection		X							X	
3.3.1.1.1i	Geographic area		X							X	
3.3.1.1.1j	WRS (path/row) scene identifier		X							X	
3.3.1.1.1k	Internal calibrator (IC) or calibration parameter pile (CPF) (default = CPF)		X							X	
3.3.1.1.2	Data availability notification specifying the location of associated L0R product files ready for retrieval		X							X	
3.3.1.1.3	L0R product files (includes L0R image data, PCD, MSCD, and associated calibration files), internal calibrator, and calibration parameter		X							X	
3.3.1.1.4	Production status request		X							X	
3.3.1.1.5	Product cancellation request		X							X	
3.3.1.1.6	Product problem report (trouble ticket)		X							X	
3.3.1.2	LPGS shall provide the capability to create and send L0R product requests to the ECS.	X	X							X	
3.3.1.3	LPGS shall coordinate resolution of data transfer problems with any L0R product file with the ECS.		X							X	X
3.3.1.3.1	LPGS shall be able to detect data transfer problems.		X								
3.3.1.3.2	LPGS shall be able to re-retrieve data.		X							X	
3.3.2	The LPGS shall be able to extract and process Landsat 7 ETM+ Earth image data from the L0R Earth image data file to produce radiometrically corrected L1R digital images.		X	X							

Rqmt. No.	Requirement Summary	PCS	DMS	RPS	GPS	QAS	AAS	UI	GL	HW	OPS
3.3.2.1	The LPGS shall be able to extract and process attitude, and ephemeris data from the L0R payload correction data (PCD) files.		X	X							
3.3.2.2	The LPGS shall be able to extract parameters from the L0R internal calibrator or calibration parameter file for use in L1R and L1G processing.		X	X							
3.3.2.3	The LPGS shall be able to generate gains and biases from either the internal calibrator data or from the calibration parameter file. The default shall be the calibration parameter file.			X							
3.3.2.4	The LPGS shall be able to extract and process mirror scan correction coefficients from the L0R MSCD file to determine scan line quality.			X							
3.3.2.5	The LPGS shall be capable of detecting the following image artifacts:			X							
3.3.2.5.1	Striping			X							
3.3.2.5.2	Banding			X							
3.3.2.5.3	Coherent noise			X							
3.3.2.5.4	Deleted			X							
3.3.2.5.5	Scan-correlated shift			X							
3.3.2.5.6	Saturated detectors			X							
3.3.2.5.7	Dropped scan lines			X							
3.3.2.6	The LPGS shall be capable of characterizing the following image artifacts:										
3.3.2.6.1	Striping			X							
3.3.2.6.2	Banding			X							
3.3.2.6.3	Coherent noise			X							
3.3.2.6.4	Deleted										
3.3.2.6.5	Deleted										
3.3.2.6.6	Saturated detectors			X							
3.3.2.6.7	Dropped scan lines			X							
3.3.2.7	The LPGS shall be capable of applying compensation for the following image artifacts:										
3.3.2.7.1	Striping			X							
3.3.2.7.2	Banding			X							
3.3.2.7.3	Coherent noise			X							

Rqmt. No.	Requirement Summary	PCS	DMS	RPS	GPS	QAS	AAS	UI	GL	HW	OPS
3.3.2.7.4	Memory effect			X							
3.3.2.7.5	Scan correlated shift			X							
3.3.2.7.6	Inoperable detectors			X							
3.3.2.7.7	Saturated detectors			X							
3.3.2.7.8	Dropped scan lines			X							
3.3.2.8	The LPGS shall be capable of applying compensation for gain changes within a requested L1 scene or subinterval as identified in the Level 0R metadata.			X							
3.3.2.9	The LPGS shall be capable of producing L1R data from L0R data for both the ascending and descending portions of the Landsat 7 orbit.			X							
3.3.2.10	The LPGS shall be able to produce L1R digital images for any combination of the eight spectral channels.			X							
3.3.2.11	The LPGS shall assemble and append to the L1R digital images all of the applicable metadata and quality and accounting data gathered in the construction of the L1R digital image. The complete L1R digital image package contains the following data elements as a minimum:		X								
3.3.2.11.1	Level 1R digital image (all requested bands)		X								
3.3.2.11.2	L1 metadata file		X								
3.3.2.11.3	Quality and accounting file		X								
3.3.3	The LPGS shall be able to extract and process Landsat 7 ETM+ Earth image data from the L1R Earth image data files to produce systematically corrected L1G digital images.				X						
3.3.3.1	The LPGS shall have the capability to resample L1R digital images and apply the following map projections:				X						
3.3.3.1.1	Space oblique Mercator				X						
3.3.3.1.2	Universal Transverse Mercator (UTM)				X						
3.3.3.1.3	Lambert conformal conic				X						
3.3.3.1.4	Transverse Mercator				X						
3.3.3.1.5	Oblique Mercator				X						

Rqmt. No.	Requirement Summary	PCS	DMS	RPS	GPS	QAS	AAS	UI	GL	HW	OPS
3.3.3.1.6	Polyconic				X						
3.3.3.1.7	Polar stereographic				X						
3.3.3.2	The LPGS shall support the following compensation resampling methods:										
3.3.3.2.1	Nearest neighbor				X						
3.3.3.2.2	Cubic convolution				X						
3.3.3.2.3	Modulation Transfer Function (MTF)				X						
3.3.3.3	The LPGS shall have the capability to produce L1G digital images with the following grid cell characteristics:										
3.3.3.3.1	Grid cell size is variable from 15M to 60M in 0.001M increments				X						
3.3.3.3.2	Grid cell size is independently variable between spectral bands				X						
3.3.3.4	The LPGS shall produce L1G digital images that are spatially continuous between contiguous partial subintervals or WRS scenes.				X						
3.3.3.5	The LPGS shall have the capability to generate L1G digital images oriented by the following:				X						
3.3.3.5.1	Oriented to Nominal Path				X						
3.3.3.5.2	Oriented to North Up				X						
3.3.3.6	The LPGS shall be capable of producing L1G data from L0R data for both the ascending and descending portions of the Landsat 7 orbit.				X						
3.3.3.7	The LPGS shall be able to produce L1G digital images for any combination of the eight spectral channels.				X						
3.3.3.8	The LPGS shall assemble and append to the L1G digital images all of the applicable metadata, quality and accounting data gathered in the construction of the L1G digital image. The complete L1G digital image package contains the following data elements as a minimum:		X								

Rqmt. No.	Requirement Summary	PCS	DMS	RPS	GPS	QAS	AAS	UI	GL	HW	OPS
3.3.3.8.1	Level 1G digital Image (all requested bands)		X								
3.3.3.8.2	L1 metadata file		X								
3.3.3.8.3	Quality and accounting file		X								
3.3.4	Generate L1 metadata file.										
3.3.4.1	The LPGS shall generate ancillary L1R digital image data that describes the contents, processing parameters, and quality indicators of the L1R digital image.		X	X							X
3.3.4.2	The LPGS shall generate ancillary L1G digital image that describes the contents, processing parameters, and quality indicators of the L1G digital image.		X		X						X
3.3.4.3	The LPGS shall generate and append processing summary indicators specifying the algorithms applied to the Level 1 digital images.		X								
3.3.5	Assess L1 product quality.										
3.3.5.1	The LPGS shall support automatic assessment of L1 digital image quality.					X					
3.3.5.2	The LPGS shall be able to optionally display any single band of the L1R digital image for visual quality assessment.					X	X				X
3.3.5.3	The LPGS shall be able to optionally display any single band of the L1G digital image for visual quality assessment					X	X				X
3.3.5.4	The LPGS shall be able to optionally print a color hardcopy of the display of any band(s) of the L1R digital image for visual quality assessment.					X	X				X
3.3.5.5	The LPGS shall be able to optionally print a color hardcopy of the display of any band(s) of the L1G digital image for visual quality assessment.					X	X				X
3.3.6	Transfer L1 file(s).										
3.3.6.1	The LPGS shall be able to output L1 digital images in the following formats:										

Rqmt. No.	Requirement Summary	PCS	DMS	RPS	GPS	QAS	AAS	UI	GL	HW	OPS
3.3.6.1.1	HDF-EOS (L1R and L1G)		X								
3.3.6.1.2	EOSAT FAST-Format (L1G only)		X								
3.3.6.1.3	GeoTIFF (L1G only)		X								
3.3.6.2	The LPGS shall transfer L1 files to ECS per the ECS to LPGS ICD.		X								
3.3.6.3	The LPGS shall provide the capability to display LPGS Level 1 file transfer summary upon operator request.		X								X
3.3.6.4	The LPGS shall be able to detect files that have been successfully transferred.		X								
3.3.6.5	The LPGS shall be able to mark successfully transferred files as candidates for deletion from LPGS temporary storage.		X								
3.3.7	Data storage										
3.3.7.1	The LPGS shall be able to provide temporary online storage for the equivalent of 3 days of completed products.		X							X	
3.3.7.2	The LPGS shall be able retransmit files located in temporary storage.		X							X	
3.3.7.3	The LPGS shall be able to store Level 1 processing information on line for 90 days.		X								
3.3.7.4	The LPGS shall be able to transfer Level 1 processing information to offline storage after 90 days.		X								X
3.3.7.5	The LPGS shall be able to recover, display, and print Level 1 processing information located on offline storage for the life of the mission.	X	X							X	X
3.3.7.6	The LPGS shall be able to provide temporary online storage for up to 25 L0R scene equivalents and associated input files.		X							X	
3.3.8	Control LPGS operations.										
3.3.8.1	LPGS shall allow the operator to select thresholds for statistics and errors reported by the LPGS.	X						X			X

Rqmt. No.	Requirement Summary	PCS	DMS	RPS	GPS	QAS	AAS	UI	GL	HW	OPS
3.3.8.2	The LPGS shall automatically generate messages and alarms to alert the operator of LPGS results and errors exceeding operator selected thresholds.	X		X	X	X					X
3.3.8.3	The LPGS shall generate intermediate processing summaries on a periodic basis according to operator specification.	X		X	X			X			X
3.3.8.4	The LPGS shall provide an option to display L1 digital image quality status and statistics at operator request.	X				X	X	X			X
3.3.8.5	The LPGS shall provide an option to print L1 digital image quality status and statistics at operator request.	X				X	X	X		X	X
3.3.8.6	The LPGS shall provide the capability to manually override the LPGS automated processing functions.	X						X			X
3.3.8.7	The LPGS shall provide the manual capability to cancel Level 1 processing prior to completion of digital image generation.	X						X			X
3.3.8.8	The LPGS shall be able to display and print trouble tickets received from ECS.	X				X	X			X	X
4	LPGS Performance Requirements										
4.1	Performance Requirements.										
4.1.1	The LPGS shall be capable of processing a volume of data equivalent to 28 (accounts for 10 percent of LPGS internal reprocessing) standard L0R WRS scenes to Level 1 digital images each day.		X	X	X					X	
4.1.2	The LPGS shall contribute no greater than .7 percent uncertainty to absolute radiometric accuracy during the generation of L1R and 1G digital images.			X	X						

Rqmt. No.	Requirement Summary	PCS	DMS	RPS	GPS	QAS	AAS	UI	GL	HW	OPS
4.1.3	The LPGS shall contribute circular errors no greater than 1.8 m, 1 sigma, in the production of systematically corrected L1G digital images.				X						
4.1.4	The LPGS shall provide at least 110 percent of the processing throughput capability required to satisfy the worst case processor loading.		X	X	X					X	
4.1.5	The LPGS shall provide at least 125 percent of the random access memory capacity required to satisfy the worst case memory loading.		X	X	X					X	
4.1.6	The LPGS shall provide at least 125 percent of the peripheral storage capacity required to satisfy the worst case peripheral storage loading.		X							X	
4.1.7	Deleted										
4.1.8	The LPGS shall produce Level 1G products that are accurate to within 250 meters cross track and 250 meters along track using geometric calibration information generated by IAS and contained in the associated calibration parameter file.				X						
4.2	External Interface Performance Requirements										
4.2.1	The LPGS shall be able to ingest from ECS a data volume equivalent to 3 WRS scenes' worth of standard L0R data for each Level 1 digital image request.		X							X	
4.2.2	The LPGS shall have the capability to support the transfer to ECS of the equivalent of a minimum of 25 WRS sized Level 1 digital images per day.		X							X	
4.2.3	The LPGS-ECS interface shall provide the capability to transfer to the ECS at least 33 gigabytes of Level 1 output files per day.		X							X	

Rqmt. No.	Requirement Summary	PCS	DMS	RPS	GPS	QAS	AAS	UI	GL	HW	OPS
4.3	Reliability, maintainability, and availability.										
4.3.1	The LPGS shall provide an operational availability of .96 (TBR).	X	X	X	X	X	X			X	
4.3.2	The LPGS shall support a mean time to restore (MTTR) capability of 4 hours (TBR).	X	X	X	X	X	X			X	
4.4	Security.										
4.4.1	The LPGS shall provide system, network, and operations security according to the ESDIS security policy (Applicable Document 8) and the NASA AIS Handbook (Applicable Document 9).	X	X	X	X	X	X			X	X

Appendix B. LPGS Software Size Estimates

B.1   LPGS Estimated Lines of Code

Table B–1 presents delivered source instructions (DSI) estimates for LPGS software based on a preliminary design of six LPGS subsystems and software modules including the database and global routines. The DSI estimate is based on a minimum of 300 to 500 DSI per module. No software size reduction factor has been applied at this time to account for the reuse of any software building blocks available from other projects. The LPGS software estimates will be reviewed again and refined at the completion of the LPGS detail design phase.

Table B–1. DSI Estimates for LPGS Software at Preliminary Design

LPGS Software Subsystem	No. of Tasks	No of Modules	Estimated DSI
Process Control Subsystem	4	35	10,000
Data Management Subsystem	7	45	25,000
Radiometric Processing Subsystem	–	–	24,000
Geometric Processing Subsystem	–	–	40,000
Quality Assessment Subsystem	6	19	3000
Anomaly Analysis Subsystem	4	6	2,500
User Interface	–	37	5,000
Database	–	–	7,500
Global Routines	–	6	2,000
Analysis Tools[†]	–	3	2,500
Test / Diagnostics[†]	–	3	1,500
Total			**123 KDSI**

[†] A minimum of 500 DSIs each are assumed for database, analysis tools and test / diagnostic software for each LPGS subsystem.